Blood

I. Key Functions

1. Respiration – transport of O2 and CO2 to and from tissues

2. Nutrition – transport of absorbed food materials

3. Excretion – transport of metabolic wastes to kidneys, lungs, skin, intestines for removal

4. Acid-Base Balance – maintenance

5. Water Balance – regulation

6. Body Temperature – distribution of body heat

7. Defense – White blood cells and antibodies

8. Hormone transport

9. Metabolite transport

10. Coagulation

II. Blood Contents

A. Total blood volume = 5.5L

B. Erythrocytes

1. Make up about 45% of total blood volume

2. About 2.5L of RBCs

C. Plasma

1. The remaining 3L of blood volume

2. About 93% water and 7% dissolved substances

a. Dissolved substances include proteins, small molecules, and waste

3. No cells

D. Serum

1. Plasma without the clotting proteins

E. Buffy Coat

1. Contains the leukocytes and platelets

III. Cellular Components of Blood

A. Stains for a Blood Smear

1. Eosin – acidic dye; stains basic components red

2. Methylene blue – basic dye; stains acidic components blue

3. Azure – stains cytoplasmic granules containing proteins and proteoglycans

B. Erythrocytes

1. Make up the vast majority of the cellular component of blood

2. Biconcave shape, reversible deformity

3. Carry mostly hemoglobin (90% of dry weight)

4. Lack a nucleus and organelles

5. Life span of ~120 days

6. Gender Differences

a. Men tend to have more RBCs than women

b. Also have a higher hemoglobin concentration

7. Hematocrit

a. Estimation of percentage of erythrocytes in blood (packed RBC volume)

b. Blood collected : EDTA-anticoagulated whole blood, purple top tube

c. Rejected if blood is hemolyzed or clotted

d. Hemoglobin tests are done the same way except no EDTA

8. Spectrin

a. Human RBC membrane protein

b. Interacts with actin and other proteins to allow RBC to deform as needed

i. Other proteins include ankyrin and band proteins

c. Interactions occur on the inside of the membrane

d. Hereditary Spherocytosis

i. Mutations in any of the involved proteins may cause disease

ii. Disease than weakens the membrane and makes cell prone to lysis

IV. White Blood Cells – Leukocytes

A. Granulocytes

1. Neutrophils

a. Make up the majority of leukocytes

b. Multi-lobed nucleus

c. Professional phagocytes

d. Contain azurophilic granules to kill pathogens

e. Elevated counts during bacterial infection

2. Eosinophils

a. Fewer in number than neutrophils

b. Bi-lobed nucleus

c. Important for allergic reactions and parasitic infections

3. Basophils

a. Very small quantity

b. 2-3 irregularly shaped lobed nucleus

c. Has large granules in the cytoplasm

d. Acts as an initiator in the inflammatory process

4. Platelets

a. Also called thrombocytes

b. Contain no nucleus

c. Originate by budding off from megakaryocytes in the BM

d. Contain granules with PDGF, ATP and serotonin, and lysosomes

e. Required for blood clotting

f. Disc-like structure maintained by MT bands under the plasma membrane

B. Agranulocytes

1. Monocytes

a. Largest cells that circulate in the blood

b. Become macrophages when they enter tissues

c. Produce cytokines and can act as an APC

d. Kidney/U-shaped nucleus

2. B-lymphocytes

a. Humoral Immunity – activated B-lymphocytes become plasma cells

b. Plasma cells produce antibodies, which circulate in the blood and lymph

c. Originate and mature in the BM

d. Migrate to peripheral lymphoid organs following maturation

3. T-lymphocytes

a. Make up ~70% of circulating lymphocytes

b. Cellular immunity

c. CD4 T-cells are required to activate B-cells, others kill directly (CD8)

d. Originate in BM and mature in the thymus

e. Migrate to peripheral lymphoid organs following maturation

C. Cellular Distribution of WBC

1. Percentages of Total Leukocytes

a. Neutrophils – 50-70%

i. Life span of <1 week

b. Eosinophils – 1-4%

i. Life span of <2 weeks

c. Basophils – 0.1-0.3%

i. Life span of 1-2 years

d. Monocytes 2-8%

i. Life span of a few days in blood, months in tissues

e. Lymphocytes – 20-40%

i. Life span of several months to several years

f. Platelets – 250,000 per mL of blood

D. Humoral Immunity

1. Five Classes of Antibodies

a. IgG – 80%

i. Immunity against pathogens in extracellular fluid

b. IgM – 5%

i. Same function as IgG, just not as good at it

c. IgA – 15%

i. Mucosal immunity, secreted in breast milk

d. IgD - <1%

i. Assists in B-cell activation and antigen recognition

e. IgE - <1%

i. Defense against parasites and allergic reactions

2. Antibody Structure

a. Constant region

b. Heavy chain and light chain arms

c. Variable region at ends of the arms where antigen binds

E. Cell-Mediated Immunity

1. Immune response that does not involve antibodies or complement

2. Antigen presentation to CD4 helper T-cells

a. APC presents antigen via MHC II

b. CD4 cells signal adaptive (CD8, B-cells) and innate (MΦ, NK) cells

c. Bind to and activate B-cells that respond to the same antigen

3. Antigen Presenting

a. Only possible by dendritic cells, macrophages, and B-cells

b. Phagocytosis and processing of pathogen, then display via MHC II

4. HIV

a. HIV virus binds to CCR5 chemokine receptor on CD4 cells

b. Essentially eliminates CD4 cells from the leukocyte population